PTO 09-7360

CC=JP
DATE=20000811
KIND=Kokai
PN=2000224829

LINEAR VIBRATION ACTUATOR
[RINIA SHINDO AKUCHUETA]

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UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. AUGUST 2009
TRANSLATED BY Schreiber Translations, Inc.

PUBLICATION COUNTRY	(10):	Japan
DOCUMENT NUMBER	(11):	2000224829
DOCUMENT KIND	(12):	Kokai
PUBLICATION DATE	(43):	20000811
APPLICATION NUMBER	(21):	1123621
APPLICATION DATE	(22):	19990201
INTERNATIONAL CLASSIFICATION	(51):	H 02 K 33/16 33/06
PRIORITY COUNTRY	(33):	
PRIORITY NUMBER	(31):	
PRIORITY DATE	(32):	
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DESIGNATED CONTRACTING STATES	(81):	
TITLE	(54):	LINEAR VIBRATION ACTUATOR
FOREIGN TITLE	[54A]:	Rinia Shindo Akuchueta

[Scope of Claims]

1. A linear vibration actuator, characterized by the fact that it is equipped with a first magnetic material yoke with a cross section of an approximate E shape having both ends and a central part; a second magnetic material yoke that is magnetically coupled with at least one of the above-mentioned both ends of the above-mentioned first magnetic material yoke; an excitation coil that is wound on the above-mentioned central part of the above-mentioned first magnetic material yoke; and a movable magnet that is arranged in a magnetic cavity formed between the above-mentioned first magnetic material yoke and the above-mentioned second magnetic material yoke.

2. The linear vibration actuator of Claim 1, characterized by the fact that in the above-mentioned first material yoke, the above-mentioned both ends are protruded from the above-mentioned central part.

3. The linear vibration actuator of Claim 2, characterized by the fact that the above-mentioned second

[1] Numbers in the margin indicate pagination in the foreign text.

magnetic material yoke has a cross section with an approximate I shape.

4. The linear vibration actuator of Claim 1, characterized by the fact that the above-mentioned both ends and the above-mentioned central part of the above-mentioned first material yoke have the same height; and the above-mentioned second magnetic material yoke has a cross section with an approximate コ shape.

5. The linear vibration actuator of Claim 1, characterized by the fact that the above-mentioned both ends and the above-mentioned central part of the above-mentioned first material yoke have the same height; and the above-mentioned second magnetic material yoke has a cross section with an approximate L shape.

6. The linear vibration actuator of Claim 1, characterized by the fact that in the above-mentioned first magnetic material yoke, one end of the above-mentioned both ends is protruded from the other end with the same height as that of the above-mentioned central part; and the above-mentioned second magnetic material yoke has a cross section with an approximate I shape.

7. The linear vibration actuator of any of Claims 1-6, characterized by the fact that the above-mentioned movable magnet includes a tubular bobbin and permanent

magnets that are arranged in the above-mentioned bobbin and are pressed and held by two springs so that they are sandwiched from both ends.

[Detailed description of the invention]

[0001]

(Industrial application field)

The present invention pertains to a linear vibration actuator. In particular, the present invention pertains to a linear vibration actuator usable in pocket bells and vibration alarms of portable phones, for instance.

[0002]

(Prior art)

As a conventional linear vibration actuator 1, a movable permanent magnet type shown in Figure 7 is representative. In other words, the vibration actuator 1 includes a fixed part 6 consisting of a first magnetic material yoke 3 with an E-shaped cross section having an excitation coil 2 and a second magnetic material yoke 5 with an I-shaped cross section, which is arranged via the yoke 3 and gaps 4 and 4, and a movable part 8 consisting of permanent magnets that are arranged in a magnetic cavity 7 of the fixed part 6. In addition, if a current is sent to the excitation coil 2, since a magnetic flux as shown in

the figure is generated to become an electromagnet of S-N-S poles as shown in the figure, a thrust that is exerted on the right shown by an arrowhead is generated in the magnet as the movable part 8.

[0003]

(Problems to be solved by the invention)

However, in the above-mentioned structure, the gaps exist in a magnetic circuit consisting of the first magnetic material yoke 3 with an E-shaped cross section having the excitation coil 2 and the second magnetic material yoke 5 with an I-shaped cross section, and when the magnetic flux is maximum, an equivalent circuit of the magnetic circuit as shown in Figure 8 is formed. Since the gaps cause a magnetic resistance, it is necessary to increase the amount of magnet constituting the movable part 8. As a result, the amount of expensive magnet must be increased, raising the total cost.

[0004] For this reason, the main purpose of the present invention is to provide an inexpensive linear vibration actuator in which the gap of a magnetic circuit is reduced by a simple constitution.

[0005]

(Means to solve the problems)

The present invention is a linear vibration actuator equipped with a first magnetic material yoke with a cross section of an approximate E shape having both ends and a central part, a second magnetic material yoke that is magnetically coupled with at least one of both ends of the first magnetic material yoke, an excitation coil that is wound on the central part of the first magnetic material yoke, and a movable magnet that is arranged in a magnetic cavity formed between the first magnetic material yoke and the second magnetic material yoke.

[0006]

(Operation)

In the gap of the magnetic circuit that is formed by the first magnetic material yoke and the second magnetic material yoke, for example, at least its one side is closed by the second magnetic material yoke, and the magnetic resistance is lowered. For this reason, the amount of movable magnet required for obtaining the same amount of magnetic flux can also be reduced.

[0007]

(Effects of the invention)

According to the present invention, since the gap of the magnetic circuit can be reduced by a simple constitution, the amount of movable magnet is also reduced. As a result, an inexpensive linear vibration actuator can be provided. The above-mentioned purpose, other purposes, characteristics, and advantages of the present invention will be further clarified by a detailed description of the following application examples referring to the figures.

[0008]

(Application examples)

Application examples of the present invention will be described based on Figures 1-6. A linear vibration actuator 10 of an application example of the present invention, as shown in Figure 1, consists of a fixed part, which includes a first magnetic material yoke 12 with a cross section of an approximate E shape, an excitation coil 14 that is mounted on the first magnetic material yoke 12, and a second magnetic material yoke 16 for forming a magnetic circuit having a gap by being magnetically coupled with the first magnetic material yoke 12, and a movable part that includes a movable magnet 20, which is arranged in a magnetic cavity 18 that is formed by the first

magnetic material yoke 12 and the second magnetic material yoke 16.

[0009] The first magnetic material yoke 12 has both ends 12a and 12a and a central part 12b with a height lower than that of these two ends, and the excitation coil 14 is wound on the central part 12b. In addition, the second magnetic material yoke 16 is a flat plate with a cross section of an approximate I shape and forms a magnetic

/3

circuit by magnetically coupling both ends 12a and 12a of the first magnetic material yoke 12. An equivalent circuit of the magnetic circuit is shown in Figure 2.

[0010] On the other hand, the movable magnet 20, which is arranged in the magnetic cavity 18 formed by the first magnetic material yoke 12 and the second magnetic material yoke 16, is joined by arranging a pair of permanent magnet segments 20a and 20b, having opposite magnetization vectors in the radial direction, in the axial direction. The movable magnet 20 will be explained in further detail. For example, as shown in Figure 3, the rod-shaped permanent magnet segments 20a and 20b joined with each other are housed in a tubular bobbin 22 formed of a nonmagnetic material and arranged in the magnetic cavity 18 in a state

in which the magnet segments are pressed and held by sandwiching from both ends by two springs 24 and 24.

[0011] In the above-mentioned constitution, if a current is sent to the excitation coil 14, since a magnetic flux that is generated by the current in accordance with the direction of the current strengthens one segment side of the adjacent permanent magnet segments 20a and 20b constituting the movable magnet 20 and weakens the other segment side, a force in which the movable magnet 20 moves to the side at which the magnetic flux is strengthened is exerted, and the movable magnet 20 is displaced in the right direction or left direction. For example, in Figure 1, an electromagnet with N-S-N poles is formed, and a thrust in the right direction is exerted on the movable magnet 20. Next, if the direction of the current flowing in the excitation coil 14 is changed, the polarity of the electromagnet becomes N-S-N poles, and a thrust in the left direction is exerted on the movable magnet 20. The direction of the current is then changed in an alternate fashion, so that the movable magnet 20 is horizontally vibrated.

[0012] Specifically, in a case in which the movable magnet 20, as shown in Figure 3, is housed in the tubular bobbin 22 and arranged in the magnetic cavity 18, the permanent

magnet segments 20a and 20b integrated by joining are horizontally, linearly vibrated in a reciprocating fashion. This vibration action, for example, can be utilized as a vibration alarm for reporting an incoming call of a pocket bell or portable phone. Now, a modified example of the first application example shown in Figure 4 will be explained. In this modified example, both ends 12a and 12a of the first magnetic material yoke 12 have the same height as that of the central part 12b, and both ends of the second magnetic material yoke 16 are bent to form a sectional コ shape in which protruded parts 16a and 16a are installed. These protruded parts 16a and 16a and both ends 12a and 12a of the first magnetic material yoke 12 are magnetically coupled to form a magnetic circuit without a gap. In addition, similarly to the first application example, the movable magnet 20 is arranged in the magnetic cavity 18. The other constitutions are the same. The same symbols are given to them, and their explanation is omitted.

[0013] Next, a second application example shown in Figure 5 will be explained. In this application example, one end 12a of both ends 12a and 12a of the first magnetic material yoke 12 is held at its height, and the other end 12a is set to the same height as that of the central part 12b on which

the excitation coil 14 is wound. As a result, the second magnetic material yoke 16 with an I-shaped cross section is magnetically coupled with one end 12a of the first magnetic material yoke 12 to close the gap of the magnetic circuit; however, the gap exists between the other end 12a and the magnetic material yoke. In this case, since there are two magnetic paths, one side may be the gap as it is, and the movable magnet 20 may have the same size as that of the first application example. For example, if a pin 26 is connected to the end of the movable magnet 20 at the gap side and a piston or diaphragm not shown in the figure is connected to the pin 26 and horizontally, linearly reciprocated, a pump action can be realized.

[0014] Next, Figure 6 shows a modified example of the second application example. In this modified example, the height of both ends 12a and 12a of the first magnetic material yoke 12 and the height of the central part 12b, on which the excitation coil 14 is wound, are the same, the protruded part 16a is installed in an L-shaped cross section by bending one end of the second magnetic material yoke 16, and the protruded part 16a and one end 12a of both ends 12a and 12a of the first magnetic material yoke 12 are magnetically coupled. In this case, if the pin 26 is connected to the gap side end of the movable magnet 20 and

a piston, etc., are connected to the pin, a pump action can be realized similarly to the above-mentioned case.

[Brief description of the figures]

Figure 1 is an illustrative diagram showing an outlined constitution of the linear vibration actuator as an application example of the present invention.

Figure 2 is an equivalent circuit diagram of the application example shown in Figure 1.

Figure 3 is an illustrative diagram showing a detailed structure of a movable magnet in the application example of Figure 1.

Figure 4 is an illustrative diagram showing a modified example of the application example shown in Figure 1.

Figure 5 is an illustrative diagram showing a second application example of the present invention.

Figure 6 is an illustrative diagram showing a modified example of the second application example shown in Figure 5.

Figure 7 is an illustrative diagram showing an outlined constitution of a conventional movable magnet type linear vibration actuator.

Figure 8 is an equivalent circuit diagram of the conventional example shown in Figure 7.

[Explanation of symbols]

10 Movable magnet type liner vibration actuator

12 First magnetic material yoke

12a Both ends

12b Central part

14 Excitation coil

16 Second magnetic material yoke

16a Protruded part

18 Magnetic cavity

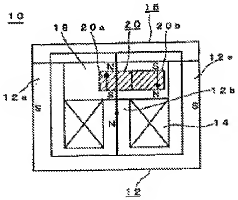
20 Movable magnet

22 Tubular bobbin

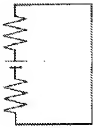
24 Spring

26 Pin

[Figure 1]



[Figure 2]



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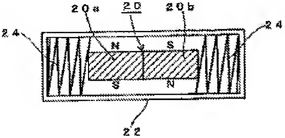
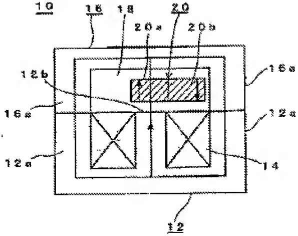
Equivalent circuit

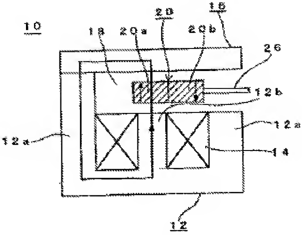
[Figure 3]



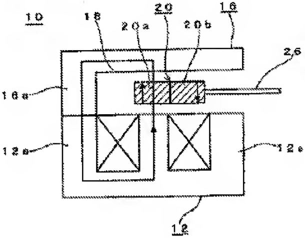
[Figure 4]



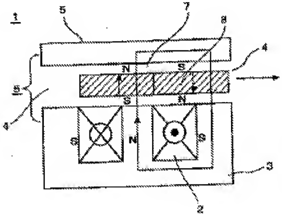
[Figure 5]



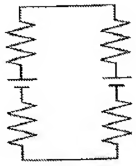
[Figure 6]



[Figure 7]



[Figure 8]



Equivalent circuit